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Financing instruments and channels for the increasing production and consumption of renewable energy: Lithuanian case

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ABSTRACT

The growing demand for energy, commitments taken to reduce greenhouse gas emissions, fossil fuel depletion and other issues enforced to accept the decision to analyze financing issues of renewable energy sector worldwide. This paper addresses two financing issues – financing channels and instruments and their impact on energy cost. The analysis revealed that the governmental support in the form of tax reductions and subsidies, and international funds are important renewable energy sector financing channels in developing countries. Availability of private resources increases under the established public–private partnership agreements. Economically advanced countries use a greater variety of financing channels and instruments. Because of high growth of renewable energy sector, some new financing channels are available. The experience of Lithuania revealed that governmental policy encourages investment into the renewable energy sector. Banks found attractive renewable energy technologies after feed-in tariffs increased. EU Structural Funds and tax incentives are available, especially in subsidizing combined cycle electricity and heat generation. Innovative financing instruments provided under the JESSICA and JEREMIE initiatives, as well as investment subsidies are favorable to develop solar energy sector in Lithuania. Seeking to expedite solar sector development in Lithuania it is essential to review a feed-in tariff, which currently is too low and impedes implementation of solar PV technologies. Solar collectors could compete in the district heating sector even without a support.

Contents

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1. Introduction

The growing demand for energy, commitments taken to reduce greenhouse gas emissions, long-standing energy security, energy poverty, fossil fuel depletion and other global as well as regional issues enforce humanity to search for ways on how to develop their energy sectors in future. It is agreed that energy sectors should be developed sustainably, which means that, apart from other actions that are necessarily to be taken, it is essential to use the economically feasible potential of renewable energy. However, because of immaturity of (some) renewable energy technologies, high capital cost and unsuitable pricing of fossil fuel (not in all countries externalities are considered when price for fossil fuel is set), the potential of renewable energy is not sufficiently used. Seeking to increase the use of renewable energy at more rapid rates, governments are implementing various support policies. During 2005–2011 the number of countries with some type of support policy more than doubled, i.e. increased from 55 (2005) to 119 (2011) countries [55]. The implementation of support policy and various support measures highly contributed to increasing the consumption of RES (further in the text RES). However, more and more often scientists state that because of the above-mentioned global and regional issues, huge new investment will be necessary into the renewable energy sector in future. Thus, issues such as how the renewable energy sector should be financed to raise capital and what impact financing instruments will have on energy cost and price for consumer are of high importance. This issue is relevant both in developed and in developing countries in times of slow recovery of the global economy.

Canadian Renewable Energy Alliance [10] segregates three renewable energy sector-related financing issues. They are (1) policies that leverage increased investment into the renewable energy sector; (2) financing channels; and (3) financing instruments. Liming [41] suggests that instead of analysis of policy that leverages increased investment, financing environment should be analyzed. It is understood as favorable regulatory, legislative and policy conditions that are critical for financing renewable energy. This issue was widely discussed in the scientific literature. However, the latter two issues are under the investigation, especially in times of economic recession and slow recovery of the economies. Thus, this paper aims at discussing existing and possible renewable energy sector financing channels and instruments and computing the impact of selected innovative financing instruments on energy cost.

In this paper financing channel is understood as the source of financing renewable energy, i.e. it shows who is financing renewable energy and answers the question “where does renewable energy sector financing sources come through?” Financing instrument is determined as a delivering method of financing.

Section 2 discusses the current status of renewables sector and tendencies of investment into it. Section 3 analyzes renewable energy sector financing channels and instruments. It provides a structural view about financing sources used to invest into the sector and it is dedicated to present financing instruments by disclosing their advantages and disadvantages. Methodology for assessment of impact of selected financing instruments on energy cost is presented in Section 4. Section 5 is dedicated to an overview of the development of RES consumption and present experience of Lithuania in its financing renewable energy sector. Possible financing channels and instruments are discussed here. Section 6 provides results of computation, which aims at assessing the impact of traditional and innovative financing instruments on energy cost. Considering the results of analysis a discussion on how the solar energy sector could be developed in Lithuania is provided. Finally, conclusions are drawn.

2. Overview of renewable energy sector development worldwide

2.1. Development of RES consumption

RES is a constituent part of the energy sector and because of benefits provided to the society and economy their role is increasing. With reference to data of International Energy Agency [32,31], RES accounted for 13.1% in global total primary energy supply (further in the text TPES) in 2004 and 2009. However, it is expected to increase the share till 18.1% at the end of 2035 [33] by reducing the share of exhausted energy sources such as oil, coal and natural gas.

Biomass and waste are the dominant types of RES, representing 9.9% in global TPES and 75.9% in global RES supply in 2009. However, their share in global RES supply has a tendency to decrease. Hydro is the second largest type of RES. It accounted for 2.3% in global TPES and 17.7% in global RES supply in 2009. This is by 0.1 and 1.0 percentage points less than in 2004. It is expected that during 2009–2035 the volume of hydro power will be increasing by 2.1% a year and will exceed the growth rates of fossil fuel and nuclear energy; however, the share of it will have a reducing trend. Geothermal energy is the third largest type of RES at the global scale. It provided 3.9% in global RES supply in 2009. This is by 0.7 percentage points more than in 2004. The contribution of wind, solar and tide energies is still minor. With reference to data of International Energy Agency [32], they accounted for 0.3% in world TPES and 2.5% in global RES supply. Because of the rapid development of wind, solar and geothermal capacities in future, the share of these types of energies will triple, i.e. will increase till 22.4% (2035) in the structure of global RES supply.

The data provided by the International Energy Agency showed that during 1990–2009 renewable energy sector grew at an average annual rate of 1.8%, which was slightly higher than the growth rate of global TPES (1.7% a year). Growth rates were particularly high for solar photovoltaic (further in the text PV) (43.5% a year) and wind power (25.1% a year) [32]. However, this is due to the fact that their bases were very low in 1990. Biogas had the third highest growth rate (14.9% a year), followed by the liquid biofuels and solar thermal, which both grew at 10.0% a year. Solid biofuels (including charcoal) experienced the slowest growth (1.2% a year) among the RES.

International Energy Agency [32] expects that renewable energy sector will remain one of the fastest growing energy sectors in the world during the next two decades. It will grow at an average annual growth rate of 2.5%, when the world primary energy demand will increase by half as big (by 1.3% a year), and will guarantee for future generations the supply of energy. But seeking that this will be realized additional new investment is required.

2.2. Tendencies of new investment into the renewable energy sector

Seeking to satisfy the growing energy needs and reduce greenhouse gas emissions, it is important to use more RES. However, wider consumption of RES is highly related to investment. This section of the paper presents the tendencies of investment into the renewable energy sector worldwide. New investment developed at very high rates during 2004–2011, except in 2009 (see Fig. 1).

Information provided in Fig. 1 shows that new investment into the renewable energy sector had a tendency to increase by a double digit prior to a global economic crisis, which picked up steam in 2009. Highly increased volume of investment through the asset finance, small distributed capacity and public markets contributed to increased volume of investment from 40 billion USD (2004) till 132 billion USD (2007). The changes in investment were associated with the fact that a lot of support policies and measures for increasing production and consumption of renewable energy were functioning, technologies improved and their cost reduced. The financial crisis and the deep economic recession started in 2008. However, this had only a small impact on investment into the renewable energy sector. Volume of investment remained positive and reached 160 billion USD in 2008. The largest share of investment (70%) was directed to energy generation projects through the category “asset finance”. During 2010–2011 new investment were further increasing. The percentage growth of investment would have been larger in 2011, if the cost of solar PV and wind technologies were not reduced [23]. Solar PV module prices fell by 50% and on-shore wind turbine prices by 5–10%. In 2011, 258 billion USD was invested. The structure of investment was the following: 61% – asset finance, 29% – small distributed capacity, 4% – public market, 2% – venture capital, 2% – government R&D and 2% – corporate R&D. Developing economies constituted 35% of this investment and 65% of investment were made in developed economies [6].

China, USA, Germany and Italy were the largest investors. In 2011, they invested 51, 48, 31 and 29 billion USD, respectively. Boom in small-scale solar PV in Italy and Germany was influenced by the impending expiry of subsidy programs. China and USA were leading in asset finance in 2011. 49.7 billion USD in China and 40.9 billion USD in USA were invested. Namely, India was considered as a country that showed the highest growth rates (63%) in investment in 2011, followed by United Kingdom (59%), Spain (45%) and Italy (43%). Investment reduced by 18% in Middle East and African countries in 2011. The main reason for this was energy policy uncertainty that emerged because of Arab Spring, which influenced the postponement of some projects.

Historically, solar and wind technologies attracted the highest shares of investment. In 2011, there were invested 147 billion USD in solar and 83.8 billion USD in wind energy sectors. Developed countries invested more in solar energy sector (80% of total new investment into the solar sector), whereas developing countries invested more into the wind energy sector (56% of total new investment into the wind sector). There were invested 10.6 billion USD in biomass sector worldwide. Biofuels, small hydro, geothermal and marine sector attracted 6.8, 5.8, 2.9 and 0.2 billion USD, respectively in 2011.

Thus, the overview of tendencies of investment disclosed that investors see renewable energy sector as of a high potential. The most attractive technologies for investors are solar and wind. The largest shares of investment go to the “asset finance” and small distributed capacity. Public market also plays a significant role in financing the renewable energy sector.

3. Review of renewable energy sector financing channels and instruments worldwide

3.1. Financing channels

Scientists and market analysts acknowledged that a lack of appropriate financing channels was the principal barrier to a wider utilization and investment into the renewable energy sector worldwide (especially in the developing countries) till early 2000. However, since 2004, investment started increasing. Scientists pointed out that the introduction and development of appropriate financing channels and instruments for both end users and industry was one of the drivers of increased investment. However, what are the currently available financial channels and instruments? This issue is analyzed in this part of the paper.

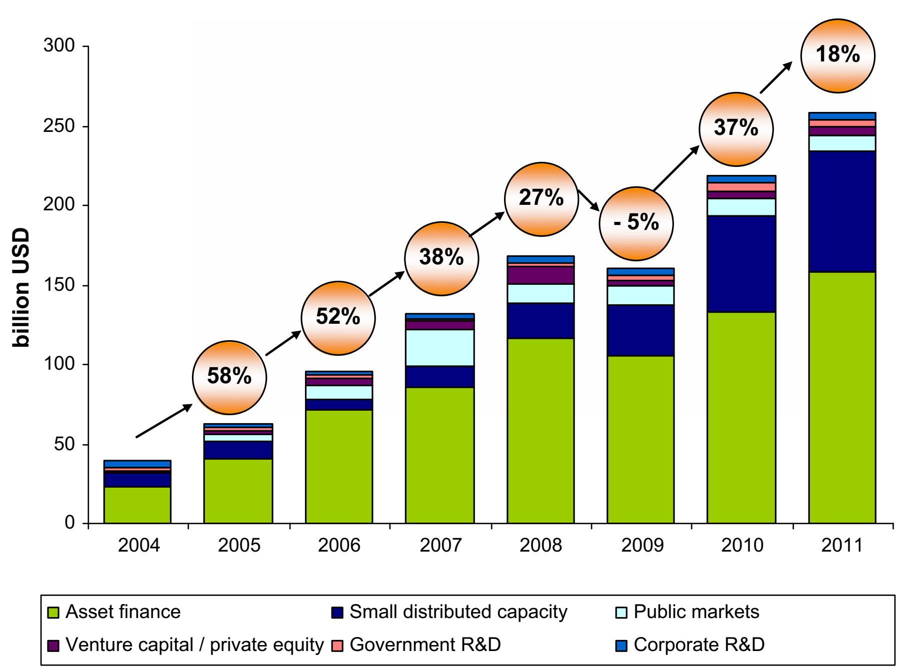

Fig. 1. Development of global new investment into the renewable energy sector by asset class during 2004–2011, billion USD [6].

The global experience suggests that currently there are a great variety of financing channels through which investment into the renewable energy sector could come.

Multilateral development banks. Based on the classification provided by World Bank [66], "multilateral development banks (further in the text MDBs) are institutions that provide financial support and professional advice for economic and social development activities in developing countries". The concept of MDBs refers to the World Bank Group and the following four regional development banks that deal with issues of the specific region: (1) the African Development Bank; (2) the Asian Development Bank; (3) the European Bank for Reconstruction and Development (further in the text EBRD); and (4) the Inter-American Development Bank Group. These institutions provide technical and financial assistance to developing countries and economies in transition for investment projects and policy implementation. Together MDBs provide financial assistance for implementation of infrastructure projects in the form of loans and grants; as well policy-based loans to the governments, which in exchange for the loan take commitments to undertake particular economic and financial policies. For this reason there is some concern about the policy-based loans from MDBs, especially in time of economic recession. Most of the MDBs use two types of funds. One type of fund is established to provide financial resources on market-based conditions, typically in a form of loan. However, equity investment and loan guarantees are used. This is a non-concessional financing. It is provided to middle-income, some creditworthy low-income governments and firms from the private sector. The other type of fund is employed to provide finance at below market-based conditions. This is known as a concessional financing. It is typically provided in the form of grants and loans at a below-market (or interest-free) interest rate and long loan repayment period.

Currently, MDBs play a significant role in facilitating investment into the renewable energy sector of developing countries, which transit to the sustainable energy sector. These institutions create the conditions that enable investors and commercial financiers to plan investments into the renewable energy sector and provide technical assistance for developing countries. Organizations of the World Bank Group are the leading financiers of renewable energy sector in developing countries. Their commitments reached 3.615 billion USD in 2012. This is by 21.5% more than in 2011 [67]. Commitments taken by the World Bank Group towards the renewable energy sector of developing countries increased during 1990–2012. The most significant increase was evident during the last economic recession, when long-term debt financing from the private sector markedly reduced or even became unavailable. Seeking to stimulate renewable energy sector in developing countries, the World Bank Group increased its commitments to this sector from 0.84 (2007) till 1.905 (2010) billion USD. During 1990–2009, more than half of the support was provided to East Asia and Pacific region and Sub-Saharan Africa region. The World Bank Group's share of commitments for the renewable energy sector increased noticeably compared to the total energy commitments during the last six years too. It rose to 44% in 2012 compared to 15–36% in the previous five years.

The following are described as the role of organizations of the World Bank Group in financing renewable energy sector of developing countries:

- *The International Bank for Reconstruction and Development* (further in the text IBRD) works with the specified governments of middle-income and creditworthy low-income countries and promotes sustainable development of these countries by providing market-based (hard) loans, guarantees, risk management products, as well as analytical and advisory services. The first investment into the renewable energy sector of developing countries has already come in 1999, when IBRD took commitments to finance Argentina's project the "Renewable Energy in the Rural Market". With the financial commitment of 30 million USD, this project aimed at providing the rural areas of the participating provinces with a reliable electricity supply. During the last 10 years financial commitments of IBRD to renewable energy sector increased. Currently, they reach 80–800 million USD per project. Intensity of IBRD's financial assistance reaches up to 100%, but in many cases it varies in the range of 30–60% of total eligible cost. During 1999–2013 cumulative financial commitments of IBRD to the renewable energy sector of developing countries were 3062.29 million USD. The largest volume of investment IBRD directed to the Europe and Central Asia regions. During 2009–2012 IBRD's cumulative financial commitments in Turkey and Poland were 1086.5 million USD. They were agreed as a part of commitments that aimed at increasing energy efficiency and reducing greenhouse gas emissions. Financial commitments to the Latin America and Caribbean region were 866.3 million USD during 1999–2012. Mainly they were directed to achieve reduction of greenhouse gas emissions through the use of RES in rural areas and in agri-business. Thus far China attracts financial assistance from IBRD, although this assistance is under discussion, since China could raise financial resources from the capital markets. In 2013, IBRD took commitment to finance three projects in China, the total value of which is 1245.58 million USD (financial assistance from IBRD is 400 million USD, from which commitments to the renewable energy sector – 142.7 million USD). The soundest project is the "Beijing Rooftop Solar Photovoltaic Scale-Up (Sunshine Schools, China)". It aims at increasing the share of clean energy in electricity consumption. It is planned to install 100 MW of distributed rooftop PV systems in 800 schools of Beijing.
- *The International Development Association* (further in the text IDA) provides interest-free (soft) loans with an extended repayment period, grants, technical assistance and policy advices to the poorest world countries that are not covered by support from IBRD. Since these countries have little or no possibilities to borrow on the market terms, financial and technical assistance provided by IDA is vital for these countries. During 2002–2012 IDA's commitment to the renewable energy sector (excluding large hydro) was 1144.0 million USD. 58% of investment was directed to Asia region and 41% to the Africa region. During the analyzed time period IDA provided financial and technical assistance for 45 projects. Its loans and grants were used for various purposes, but the largest amount of investment was targeted to increase energy efficiency in the power sector, increase quality of electricity supply and access to electricity. IDA's contribution to a small-scale project implementation is up to 100% of the total eligible cost, but for large projects it is 40–80%. Together with IBRD, IDA remains the largest financier of renewable energy sector in developing countries. In 1990–2009, cumulative commitments of IBRD and IDA to new renewable energy were 2757.0 million USD and large hydro power energy – 4905.0 million USD.
- *The Global Environment Facility* (further in the text GEF) helps developing countries fund projects and programs that protect the global environment. GEF is the World Bank Group's largest partner in the area of financing renewable energy sector. Its cumulative commitments to the renewable energy sector were 629 million USD during 1992–2009. In the field of RES, GEF finance national, regional and global level projects.
- *The International Finance Corporation* (further in the text IFC) aims at promoting economic development through the private sector. Working with business partners, it invests in private enterprises of developing countries and provides long-

term loans, guarantees, risk management and advisory services. Currently, it actively participates in the renewable energy sector by investing and providing advisory services to private enterprises across all parts of the supply chain (for example, for manufacturing of wind turbines, solar PV and their components). Since 1992, IFC invested more than 1.1 billion USD in renewable energy sector and it planned to triple its commitments during 2009–2011. IFC supports only proven renewable energy technologies, including biomass, geothermal, hydro, solar and wind. IFC invests in activities that have a potential to reduce costs and build scale across the value chain.

Regional development banks. However, because of limited financial resources and due to performance principals, which say that exposure of MDBs to a particular sector cannot to be too high, the role of MDBs in financing renewable energy sector is restricted. Thus, Regional development banks (further in the text RDBs), which focus on issues of a specific continent or a region, become active in financing renewable energy sector. Examples of formal RDBs are (1) the Asian Development Bank; (2) the African Development Bank; (3) the European Bank for Reconstruction and Development; (4) the Inter-American Development Bank; (5) the Islamic Development Bank, (6) the East Africa Development Bank; and (7) Development Bank of South Africa. These RDBs aim at fostering economic development and social progress of their member countries and provide financial and technical assistance for various sectors. Infrastructure remains one of the priority sectors through which RDBs support renewable energy projects. Up to now the support to the renewable energy sector was increasing. This is due to the RDBs' strict targets towards climate change. The Inter-American Development Bank and the Asian Development Bank are the banks that increased lending mostly during time of the last economic recession. Currently, the Inter-American Development Bank supports programs that contribute to the improvement of energy efficiency, promote cross-border energy integration and diversify the energy mix by including RES. The Inter-American Development Bank finances large-scale wind farms, solar power systems for rural regions and biofuel facilities that co-generate electricity [30]. It seeks to attain the annual lending target of 25% for climate change, renewable energy and environmental sustainability at the end of the 2012–2015 [29]. The Asian Development Bank also took financial commitment towards the renewable energy sector. It set a target to invest 2 billion USD annually in clean energy up to the end of 2013. The target was already reached in 2011, when 2.1 billion USD was invested. The Asian Development Bank actively participates in financing solar and wind energy. In 2010, it launched the “Asia Solar Energy Initiative”, which aims at identifying, developing and implementing 3 GW of solar electricity generation by 2013. This is the first new initiative to accelerate the adoption of low-carbon technologies in Asia and the Pacific region. Besides it launched the “Quantum Leap in Wind Initiative”, which provides technical assistance to (1) draw up wind energy development road maps, which lead to an additional 1 GW of installed wind power in selected countries during 2010–2015, with total investment of more than 1.0 billion USD; (2) assess wind resources in Mongolia, the Philippines, Sri Lank and Vietnam; and (3) develop business and financing models to make wind projects in participating countries more bankable [1]. These and other initiatives, as well as various programs implemented by RDBs reduce risks related to the implementation of renewable energy projects and contribute to increased investment into the renewable energy sector.

United Nations. United Nations also contribute to the development and investments into the renewable energy sector of developing countries [26]. The United Nations Environment Program's Rural Energy Enterprise Development Program (further in the text REED program) focuses on enterprise development and provides seed financing for entrepreneurs in renewable energy in developing countries. Today REED program is implementing in five countries of West and Southern Africa (namely, Senegal, Mali, Ghana, Zambia and Tanzania), Northeast Brazil and China's Yunnan Province [62].

Both MDBs, RDBs and United Nations are examples of multilateral assistance, which, according to Bruggink [8], is used to promote green growth and address large-scale, close to market technologies. This assistance differs from a bilateral one in a way “…bilateral agency addresses problems of persistent poverty (energy access) that concern relatively small-scale and pre-commercial technologies. Such technologies require additional research and development and operate in the policy context of emergent, socially-inclusive markets and small-scale business development that are not the primary concern of existing multinational firms…”.

Government and private sector. Regardless to mentioned financing channels used in developing countries, additional are available. Among others, Liming [41] and Mainali and Silveira [44] distinguished additional two important types of renewable energy sector financing channels in developing countries. They are (1) government; and (2) commercial banks (or private sector).

The role of the government in financing renewable energy sector is diverse. It highly depends upon the economic, social and political context with which the government has to deal. Thus, the government's role in financing renewable energy sector is both active and passive. The government that solves energy security, job creation, competitiveness and economic growth issues sees the renewable energy sector as of high importance. Thus, the government takes a leading position in financing renewable energy sector. Liming [41] argues that governmental finance is the most important channel for financing renewable energy in developing countries. Its active role comes through the implementation of national programs and supply of grants for subsidization of the capital costs of equipment, loans, loan guarantees and tax incentives. Currently, its assistance to raise capital from private sector is unarguable.

Benkovic et al. [5] stated that the use of financial sources from private sector for implementation of renewable energy projects became attractive in the last few decades. These financial resources are used in the area of construction and maintenance of the public sector infrastructure, as well as in construction of industrial facilities. However, the experience of developing countries shows that renewable energy sector financing through internal private financial channels is limited in these countries. Liming [41] and Behrens [4] segregate several reasons why private sector participation is limited in developing countries. They are (1) investment into the renewable energy sector has a public good component (i.e. costs and benefits are not always borne by the same economic agents); (2) there is no effective environmental legislation in developing countries; (3) renewable energy technologies have high initial capital costs; (4) there are risks associated with higher pay-back periods; (5) higher investment risks (including market and currency risks) in developing countries require higher rates of return to compensate them; and (6) high transaction costs for small- and medium-sized projects. Thus, because renewable energy projects are of high risk and low profit and due to other barriers, they are not always attractive for private sector. Thus, additional financing channels are essential. Benkovic et al. [5] shows that public–private partnerships could be valuable to increase the investment into the renewable energy sector.

Public–private partnership is a type of cooperation between a public sector authority and representatives of the private sector for financing, revitalization, management and maintenance of infrastructure, including renewable energy projects. It represents joint ventures, when entrepreneurs and the government cooperate, contributing together to a faster and a more efficient

implementation of renewable energy projects. Benkovic et al. [5] emphasizes that such a way of renewable energy project financing enable two benefits: (1) significant financial assets are transferred from the private into the public sector, which fulfill the existing financial needs; and (2) financial risk, or responsibility, disperses, significantly professionalizing labor and services in the public sector and improving their overall quality.

Currently, various regional and global partnerships that used to finance renewable energy sector exist:

- *The Global Energy Efficiency and Renewable Energy Fund* (further in the text GEEREF) is a public–private partnership, which is structured as a fund-of-funds. It invests in private equity funds that specialize in providing equity finance to small and medium-scaled project developers and enterprises that focus on renewable energy and energy efficiency projects and/or technologies. By providing finance, GEEREF considers whether the private equity fund focuses on projects that require up to 10 million EUR equity investment. It invests mainly in emerging markets and focuses on satisfying the needs of the African, Caribbean and Pacific developing countries, as well as Latin America, Asia and neighboring states of the EU. Currently, GEEREF collaborates with 6 funds with the total commitments of 65 million EUR [24].
- *The Renewable Energy and Energy Efficiency Partnership* (further in the text REEEP) is a public–private partnership, which is supported by the governments of economically developed countries, institutions such as the OPEC Fund for International Development and contributions from the private sector. This partnership aims at increasing equity finance for small projects of up to 10 million EUR seeking to accelerate clean energy in developing countries and emerging markets. The REEEP funds support various activities, including (1) projects that scale up business models for renewable energy and energy-efficient technologies to ensure growth in existing markets and new market penetration; (2) decentralized and/or off-grid generation to extend access to energy and its related opportunities; and (3) and others. To date, REEEP funded more than 180 projects in 58 countries [56,57].
- *The Global Village Energy Partnership* (further in the text GVEP) provides loan guarantees to small businesses through its Loan Guarantee Fund and capital grants through Grant Program to developing countries. In the framework of Loan Guarantee Fund, GVEP takes some of the default risk on loans to small energy businesses, in order to increase the availability of loans. Fund is used for very small businesses. It helps with the financing of equipment purchases and inventories [25].

Banks. Based on the results of analysis prepared by Justice et al. [36], banks are recognized as an important renewable energy sector financing channel too. They provide (1) corporate lending; (2) project finance; (3) mezzanine finance; and (4) refinancing.

Justice et al. [36] and Rezessy and Bertoldi [58] argue that by providing corporate lending banks provide finance to a company to support its core or ordinary activities and usually do not put restrictions on how to allocate the received funds, if general requirements are satisfied. In case the company is required to finance the specific project, then the bank takes a decision to provide financing considering the company's general financial strength and stability. After financing is received, the company stands behind the project and the related debt but the bank has to recognize the company's asset in the case of the default. Thus, one of the biggest disadvantages of corporate finance in financing the renewable energy sector is that a company responds with all its assets to the failure of the renewable energy project.

In recent years, financing through the project finance has become an important part of corporate financing decisions. This structure involves equity investors and a syndicate of several banks, which provide loans to the activity. The loans are usually non-recourse loans, which mean that they are secured by the project asset and paid entirely from the project cash flow, rather than from the general asset of the company. The ratio of debt to equity is much higher in project finance than in corporate financing – a project with 70–80% of debt is common. Compared to the corporate lending, banks are ready to extend the length of the project finance loans to almost 15 years because they have much more control over the project. Another particularity of project financing is that it transfers the risk away from the banks and spreads it among the different sponsors [58]. This type of financing is attractive because of several reasons [49]: (1) the creditors do not have a claim on the profit from other projects if the renewable energy project fails, while corporate financing gives this right to the investors; and (2) it typically has priority on the cash flows from the project over any corporate claims.

Banks also provide mezzanine finance (subordinated debt), which is a supplementary source of financing to debt and equity and is useful in financing the technology innovation, projects, start-up, and expansion of SMEs [61]. The main advantage of mezzanine finance is that it fulfills the gap between senior debt and pure equity financing. Thus, it has features of both debt and equity. Banks that provide mezzanine finance have claims that are subordinated to senior lenders and have priority over equity investors. This type of financing is attractive to banks and other providers of mezzanine finance because it generates returns, which are higher than lending rates of bank but are lower than the returns asked by the equity investor. Because of high return requirements, mezzanine finance instruments mostly address companies with stable cash flows and high growth expectations. This is the case of renewable energy sector-related companies, for which it is cheaper to receive mezzanine finance than that which would be available on the equity market. Other advantages of mezzanine finance against other financing are the following [58,68]: (1) it does not mean losing control of the company and can allow renewable energy-related companies to raise sufficient capital to meet the debt–equity requirements; (2) it is considered as an alternative solution to portfolio guarantees. It can substitute or reduce the amount of senior debt and at the same time to reduce the risk to senior lenders; (3) instruments of mezzanine finance can be extended for 6–12 years, providing a more “patient” capital investment option; (4) it can improve credit rating of a renewable energy related company and put it in a better position to acquire further debt and equity investment; (5) repayment of mezzanine finance could start after an extended grace period or even after all senior debt was repaid.

Pension funds are found [64] as potential big players in financing of RES deployment and infrastructure on a large scale. The reasons for pension funds to enter the renewables sector are their wish for a strong growth or stable returns (around 15%) during a longer time period. The first one pension funds invest into the primary markets during the project construction phase, the latter – into the operation and maintenance of renewable energy projects. Pension funds prefer investing in on-shore wind sector.

Sovereign wealth funds are recognized to be a potential renewable energy sector financing channel. There are several good examples how sovereign wealth funds participate in financing renewable energy sector [38,45]: (1) Masdar Capital (funded by the United Arab Emirates Sovereign Wealth Fund Mubadala) invests in the commercialization of future RES technologies through two clean-tech funds. It helps its portfolio companies grow and scale up by providing capital and management

expertise; (2) Norway's sovereign wealth fund invested 3.1 billion USD in clean-tech companies in emerging economies (China, India and Brazil) and was an investor in the World Bank's Green bonds. At home large investments are being made in development of offshore wind farms; and (3) Qatar Investment Authority increased its stake to 8.4% in Iberdrola SA, which is the world's largest owner of wind farms and the biggest electricity provider in Spain.

The main features of other renewable energy sector financing channels, which are used in advanced economies, are provided in Table 1.

Thus, the analysis of literature showed that nowadays there is a great variety of financing channels through which renewable energy sector can be financed. However, Bloomberg New Energy Finance [6] emphasizes that financing channels highly depend on the stage of the life cycle of the development of the renewable energy sector; in agreement with Wüstenhagen and Menichetti [69], Kalamova et al. [37], and Bloomberg New Energy Finance [6] there are four stages of life cycle of renewable energy sector development: (1) technology research; (2) technology development; (3) equipment manufacturing; and (4) roll-out, which correspond to the stage of deployment of renewable energy generation project (see Fig. 2).

As seen from Fig. 2, sector is financed using both private and public financial sources and a mix of financial resources. Based on the global experience, it could be argued that technology research stage traditionally is the principal focus of public financing. Aiming at reducing risk for renewable energy technology researcher, technology research stage is mainly financed by the governmental and other public entity's grants and subsidies, which are not refundable.

When renewable energy technologies move out of the research to the development stage, the amount of public financing reduces. Venture capital and privative equity come into the place. Because of the high level of risk and dismissal of the requirements held by the financial institutions for receiving loans, in early stage of technology development, renewable energy technology developer is not capable of receiving financing from credit/debt markets. Instead they use financial resources of venture and private equity capitalists. These capitalists obtain equity shares in the start-up and fast growing renewable energy technology developing company and start playing a significant role in the management and technical aspects of it, including obtaining a seat on the board [61]. Although venture capital is a subset of private equity, however, some differences between financing channels are noticeable. The main ones are provided in Table 2.

Venture capital comes from several types of investors: (1) institutional; and (2) high net worth individuals. The first one investor is known as a formal venture capitalist and is a legal entity. He/she mainly invests into the non-listed newly created companies and does

Table 1
The main features of funds financing renewable energy sector [36].

Type of fund	The main features
Venture capital funds	Money raised from a wide range of sources with high-risk appetite to include insurance companies, pension funds, mutual funds, high net worth individuals; Target new technology, new markets; Interested in early-stage companies; High risk of failure in every venture; Investment horizon around 4–7 years; Return requirement is of 50–500% internal rate of return.
Private equity funds	Money raised from a wide range of sources with medium-risk appetite to include institutional investors and high net worth individuals; Target opportunities with possibility for enhanced returns; Interested in companies and projects with more mature technology, including those preparing to raise capital on public stock exchanges, demonstrator companies, or under-performing public companies; Investment horizon is 3–5 years; Return requirement is of 25% internal rate of return.
Infrastructure funds	Funds drawn from a range of institutional investors and pension funds; Target “infrastructure”, i.e. an essential asset, long duration, steady low risk cash flow; Interested in roads, railways, power generating facilities; Investment horizon is 7–10 years; Low risk and return, 15% internal rate of return.

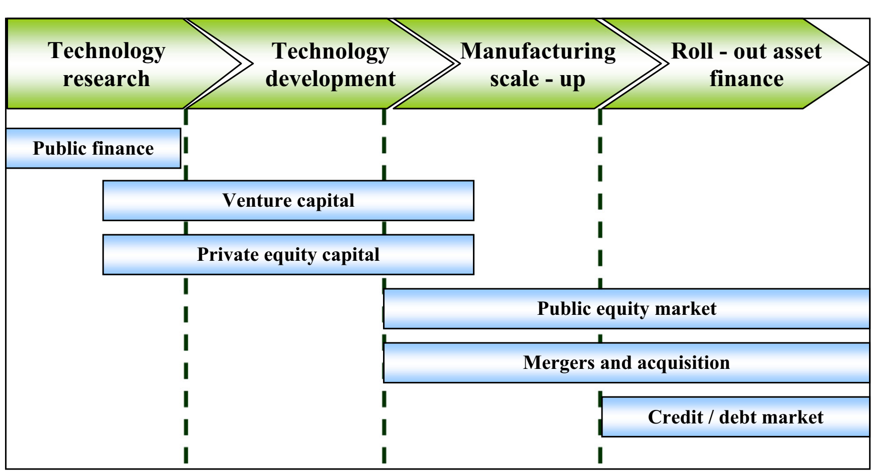

Fig. 2. Renewable energy sector financing sources in different business activities [6].

Table 2
Comparison of venture capital and private equity [47].

Criteria	Private equity (PE) capital	Venture capital (VC)
Company types	PE companies buy companies across all industries	VC investors are focused on technology, bio-tech, and clean-tech
Percent acquired	PE companies almost always buy 100% of a company in a leveraged buyouts	VC investors only acquire a minority stake – less than 50%
Size	PE companies make large investments – at least 100 million USD up into the tens of billions for large companies	VC investors investments are much smaller – often below 10 million USD for early-stage companies
Structure	PE companies use a combination of equity and debt	VC investors use only equity
Stage	PE firms buy mature, public companies	VC investors invest mostly in early-stage – sometimes pre-revenue – companies

not play in safe. The second one is an informal venture capitalist and is known as a natural entity or a “business angel”. He/she is rich and is ready to use his/her financial resources to finance risky investment. Together with the invested capital, “business angels” share their experience, knowledge and contacts. Since “business angels” are rich individual investors, they fulfill the gap between individual financing possibilities and institutional venture capital. The advantage of this type of financing channel is that “business angels” take more flexible decisions compared to institutional venture capitalists and react to changes in the surrounding environment more quickly. Although venture capitalists provide early-stage financing, they also can be a channel providing expansion financing and acquisition/buyout financing. In their analysis Hofman and Huisman [28] found that the majority of venture capital and private equity in the field of renewable energy sector focus on the seed and start-up capital (i.e. the early-stage financing) (35%), expansion financing (42%) and other financing (23%).

Private equity investment is used to trigger pre-deployment (commercially attractive RD & D) carried out by small entities. Renewable energy sector-related entities choose this type of investors due to several reasons. Unlike debt, equity does not create financial distress. This is due to the fact that payments to private equity owners depend on the success of RD & D. Besides, private equity provides small entities with collateral they need to receive a debt. However, some entities may want to avoid the influence of new equity providers, since new equity has large cost for existing equity owners, i.e. the value of their shares can decrease.

The main reasons for private equity capital and venture capital to enter the renewable energy sector are various – this sector supporting policies. The results of Bürer and Wüstenhagen [9] and Hofman and Huisman [28] disclosed that feed-in tariff was the most popular policy among venture capitalists and private equity investors during economic growth and recession periods worldwide, which had an impact on their decision to invest into the renewable energy sector. Comparing the results of 2007 and 2011, scientists observed that importance and popularity of most policies decreased during the economic recession period. Significant decrease was found in trade-based mechanisms, green quotas and certificate trading as well as CO_2 emissions trading. Economic recession period and followed cuts of subsidies in European countries influenced the popularity of several support policies; however, feed-in tariffs were still the most important, which is considered by venture capitalists and private equity investors when the decision to finance renewable energy sector is discussed. This support policy is important to venture capitalists and private equity investors, since it provides stable incentives for investors.

Financing of renewable energy generation projects is also very important and is called “asset financing”. Asset financing means that money is invested in energy generation projects, using loans and equity capital [6]. As emphasized by Kalamova et al. [37], financing the construction of renewable energy generating facilities involves a mix of equity investment from the project owners and loans from the banks (called private debt) or capital markets (called public debt, which is raised through issuing bonds). Mergers and acquisitions transactions in the renewable energy sector usually involve the sale of generating assets or project pipelines, or sale of companies that develop or manufacture technologies and services.

The analysis of renewable energy sector financing channels showed that there is a great variety of financing channels worldwide. Financing channels differ between countries; they depend on the level of country's economic development, type of RES and the stage of life cycle of renewable energy sector development.

3.2. Financing instruments

Financing instruments for development of renewable energy sector can be divided into two broad groups. They are [63] (1) governmental instruments, which are implemented through various governmental programs; (2) and instruments provided by other financing channels. Kalamova et al. [37] segregated four types of financing instruments. They are: (1) capital subsidy; (2) loan; (3) equity; and (4) mezzanine. Considering the classification of financing instruments proposed by Vassilakos et al. [63] and Kalamova et al. [37] analysis is performed. The initial analysis of renewable energy sector financing instruments reveals that they do not differ significantly between countries of different levels of economic development; therefore, it is decided to discuss them in one section of the paper.

Tax incentives are the most widely used governmental instrument [61]. It was applicable in 62 out of 195 countries in 2010 [55]. Alongside capital investment tax incentives are a supplementary instrument to facilitate investment [13]. Tax incentives are used because they promote the introduction of renewable energy in many ways [35]: (1) for renewable energy producers, they effectively increase a company's after-tax earnings; (2) for energy consumers, they reduce the cost of energy consumption, leading them to choose RES over the fossil fuels; and (3) they also help stimulate the development of a local manufacturing capacity.

Jalilvand [35] segregated 10 types of tax incentives that could be implemented to promote the introduction of renewable energy and facilitate investment into the renewable energy sector. They are (1) investment tax incentives; (2) production tax incentives; (3) property tax reductions; (4) value-added tax reductions; (5) excise (sales) tax reductions; (6) import duty reductions; (7) accelerated depreciation; (8) RD & D and equipment manufacturing tax incentives; (9) tax holidays; and (10) taxes on conventional fuels.

Investment and production tax credits, import duty reductions, value-added tax reduction or exemption are common instruments in many developed countries (USA, Canada and Australia). Additionally, tax allowances against taxable income of individuals and companies exist. For example, 55% tax allowance is applied for the installation of solar panels for the production of hot water and for the replacement of winter heating systems with systems equipped with high-efficiency heat pumps, i.e. low-temperature geothermal systems in Italy. Tax incentives are also popular in developing

countries. For example, in Philippines renewable energy projects are exempted from income tax for seven years, as well zero-value-added tax rate for renewable energy projects is applied. Reduced rate of value-added tax for energy from renewable energy is also effective in China [41]. 7% of income tax is deducted for the first 5 years on the investment of renewable energy equipment or technology, the purchased renewable energy equipment qualify for the accelerated depreciation and income tax is deducted for 10–20% of renewable energy stock owned by an individual or company in Taiwan [39]. Many developing countries have reduced import duties for equipment, which use RES. For example, South Korea has been applying 50% import duty reduction since 2009, whereas RES technology is exempt from import duty in China [41].

It is worth noting that reacting to economic recession a lot of countries reconsidered tax policy related to the renewable energy sector. For example, USA extended/increased tax credits to renewable energy sector [16]: (1) for residential sector investment tax credit of maximum 2000 USD was removed and 30% federal tax credit was approved for installation of solar and geothermal plant; (2) for business sector the previous 4000 USD cap for purchase and installation of small-scale wind was removed, but 30% federal tax credit was approved; (3) for facilities generating power from wind, closed-loop biomass, and geothermal resources renewable energy production tax credit was increased till 2.1 cent/kWh for the first 10 years of a renewable energy facility's operation. Tax credits were recognized as more efficient than cash grants in USA [48].

Capital subsidies, grants and rebates are typical instruments of the governmental organizations used to promote renewable energy sector and investment into it. They function well if they are applied to market-ready technologies that are prepared to move from the prototype stage to a mass production. They aim at reducing technology costs, demonstrating technological feasibility, revealing potential market barriers and increasing market penetration [40]. With reference to Kalamanova et al. [37] these instruments can be converted to loans or equity when the renewable energy technology achieves a commercial success. With reference to data of REN21 MAP [55], capital subsidies, grants and rebates were applied in 42 out of 195 countries in 2010. Currently, they are used in both developing and developed countries. Nonetheless, these instruments are more popular in high- and middle-income countries, with special emphasis on solar PV technologies. Capital subsidies for solar PV are common at the national, state, local and utility levels. They cover 30–50% of investment costs. With reference to Dusonchet and Telaretti [13,14] 12 western and 7 eastern EU countries use capital subsides to promote solar PV installations.

Capital subsidies for the renewable energy sector are used for the following reasons [22,12]: (1) to reduce costs for consumers and producers by giving direct support; (2) to alter the distribution of wealth or income in desirable ways; (3) to compensate for capital market imperfections that foreclose access or discriminate against identifiable groups of business enterprises; (4) to promote competition and capital subsidies are designed to offset barriers to entry; (5) the desirability of capital subsidies is attributed to perceived externalities in private sector investment. For example, capital subsidies are seen as a direct incentive for businesses to expand politically favored activities, such as pollution control or energy conservation; and (6) to promote the mobilization of private finance for renewable energy in developing countries.

Responding to economic recession and implementing European energy policy objectives, in 2009 European Parliament and the Council established a program to aid economic recovery by providing Community financial assistance to projects in the field of energy. 9 off-shore wind projects were granted using financial resources from this program. Total amount for off-shore wind projects was 565 million EUR; grants from EU could not exceed 50% of the eligible costs [20]. Grants are conducive for some of the projects to obtain the necessary loans from the banking sector during times of deep economic recession [19].

Loans are a very important renewable energy sector financing instrument. The majority of loans are provided by banks; however, governmental organizations can also act as lenders. Kalamanova et al. [37] segregated four types of loans that are provided to the renewable energy sector. They are (1) soft loans; (2) senior debt; (3) subordinate debt (mezzanine finance); and (4) lease finance.

Olmos et al. [51] argues that the later stages of technology development and demonstration are the predominant areas, where soft loans are successfully applied. Generally, at this stage conventional loans from the banking sector are rarely available because of high technology development risk, the lack of immediate revenue-generation potential to repay the loan and because a small developer's balance sheet generally does not provide sufficient collateral. Thus, public sector provides soft loans or convertible loans at the pre-deployment stage of technology development. Renewable energy sector-related companies use these loans because of several reasons [58]: (1) payback period of soft loan is extended; (2) low or zero interest rate is offered; and (3) payback grace period can be foreseen for soft loan.

Senior debts (it is provided in a form of credit line or loan) are also available to develop renewable energy sector-related activities and projects. The peculiarity of senior debt is that it is the first level of a corporation's liabilities, which means that it is paid first, ahead of all other creditors, i.e. if the RES-related company meets difficulties, and then senior debt providers are sure that they will be paid first. Thus, the advantage of senior debt, as opposed to the subordinated debt, is that it assures investor that he/she is first in seniority and is often secured by collateral. Due to its low risk, it provides the least returns to the investor, but it is a cheaper financing channel to RES-related company. Senior debts provided by the public sector can offer longer-term financing than it is available in local financial markets [68].

The results presented by Federal Ministry for the Environment [21] disclosed that financial crisis impacted on loan market. Since economic sectors were faced with reduced liquidity, financial institutions appeared more risk-averse when they lend to the renewable energy sector. Financial institutions started lending to companies that have strong balance sheets. Although during economic recession period official interest rates reduced, rates for renewable energy projects increased. The increase in rates was influenced by increased borrowing spreads. Spreads for on-shore wind farms in Western Europe increased to about 225 points over Libor/Euribor. Depending on technology used and other criteria spreads were different. For example, on-shore wind projects received smaller spreads than off-shore wind and solar PV – smaller than solar thermal. Banks also shortened the loan repayment period. Although some financial institutions were prepared to lend for 15 years (loans were provided for 18–20 years in 2007), other financial institutions offered loans for 10 or less years. Financial institutions also asked for high fees and required that debt to equity ratio was reduced.

Mezzanine finance instruments are becoming important in financing renewable energy sector, but remain little used compared to traditional loan financing. The most common instruments of mezzanine finance are the (1) subordinated loan; and (2) convertible bonds. Subordinated loan is a very common type of mezzanine finance in financing renewable energy sector. It is determined as an unsecured loan with a lower ranking in case of bankruptcy compared to senior debt. Providers of subordinated loans receive a fixed interest rate and are ranked before equity investors should the borrower be wound up. Mezzanine finance for renewable energy sector was/is provided by FIDEME and EUROFIDEME [18]. FIDEME was a 45 million EUR public–private

partnership that provided mezzanine finance (namely, convertible bonds) to the renewable energy companies in France. Financing of projects was based on the proved technologies that were verified by the French Environment and Energy Management Agency and were addressed to improve the environment. EUROFIDEME's objective is to receive stable returns by investing in sustainable development projects. EUROFIDEME invests in European electricity generated from RES projects – in solar PV, wind, hydro and biomass. The fund also invests in the experienced development companies to allow them to expand their RES asset portfolios. EUROFIDEME's investment instruments are (1) convertible bonds; and (2) equity in project companies and developers with an investment amount of 3–20 million EUR per transaction. Central American Renewable Energy and Cleaner Production Facility also provides mezzanine financing in the form of subordinated debt, convertible bond and preferred shares for renewable energy for seven countries (Belize, Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua and Panama). It finances up to 25% of project capital costs of RES projects.

Bonds. As a result of financial crisis, new options raising the debt from the capital market are required. Green bonds and notes come on the scene. The application of this type of instrument is not purely new. The use of Green bonds to finance renewable energy sector was known before the time of financial crisis. As fixed-income (sometimes variable returns are set) securities issued by the governments, multi-national banks or companies they were used to raise the capital for a project that contributes to a low carbon and climate-resilient economy [11]. Justice et al. [36] and Scholer [59] acknowledge that attractiveness of these instruments increases in case they are rated. Till 2011 Green bonds were issued predominantly as AAA-rated securities by the World Bank and other development banks and some other entities in order to raise capital specifically for climate change and green growth-related projects. Investment-grade ratings for company's notes from three rating agencies were reduced in 2012, i.e. from Fitch till BBB–, S&P till BBB– and Moody's till Baa3.

Croce et al. [11] indicate that there are many types of Green bonds that were issued and proposed, but Climate bond as a class of Green bonds is worth paying attention to. Climate bond is a fixed-income instrument, which allowed governments to raise capital, or support the private sector in raising capital, to build renewable energy generation and its enabling infrastructure and others. The demand for Green bonds comes from different institutional investors, such as the Danish pension fund ATP, the UN Join Staff Pension Fund and the Norwegian Global Fund; they are directed towards the retail sector; besides sovereign wealth funds, hedge funds and private equity also provided interest to the Green bonds. The World Bank issued over 2.3 billion USD equivalent of Green bonds through 39 transactions in 15 currencies. These were mostly 3–7 year, AAA rated, fixed- and floating-rate notes designed to raise capital for projects that aim to combat climate change in developing countries.

By summarizing what was said, it can be mentioned that availability of renewable energy sector financing instruments differs depending on the type of RES and development stage. Variety of instruments discloses that they are attractive to finance renewable energy sector. The widespread application of instruments assures that there are actual possibilities of using these financial instruments in various countries, including Lithuania. However, currently there is a low level of knowledge about the impact of these innovative instruments on electricity and heat energy cost, which is an important constituent part of energy price. Thus the following sections of the paper deal with a methodology used to assess the impact of financial instrument on cost of energy generated from RES. Levelized cost of energy method will be applied to assess how various financial instruments could impact RES energy cost.

4. Methodology for assessment of impact of renewable energy sector financial channel and instrument on RES energy cost

Levelized cost of energy (further in the text LCOE) is one of the most widely used approaches for comparison of different energy generation alternatives. It is based on the principal that considering the chosen discount rate the present value of total life-cycle cost is calculated and distributed per one unit of production unit. The LCOE approach is useful to assess competitiveness of different energy generation alternatives, possible gains for project developer, it helps make insights into macroeconomic effects (after external data are utilized); as well to compute the effect of different financing instruments on energy cost. The classical representation of the LCOE is provided in Eq. (1)

$$\mathrm{LCOE} = \frac{\sum_{t=0}^{T}(I_t + O\&M_t + F_t)/(1+d)^t}{\sum_{t=0}^{T}(C_I \cdot 8760 \cdot LF)/(1+d)^t} \tag{1}$$

where I_t – investment cost at time step t, EUR; O & M_t – operation and maintenance cost at time step t, EUR; F_t – fuel cost at time step t, EUR; C_I – installed capacity, kW (MW); LF – load factor, %; d – discount rate, %; t – life time, years.

As it is seen from LCOE representation in Eq. (1), discount rate is an important constituent part of LCOE. The results of analysis of the literature showed that a discount rate is different for various technologies and assumptions that are taken into account. For solar technologies discount rate varies in a range of 8–12% [7,54,65,53,27,34] and it is higher than a discount rate applied for assessment of LCOE of on-shore wind energy, where it is about 7–10%.

In this paper an extended LCOE approach will be applied. The advantage of the extended LCOE approach is that it allows assessing the effect of different RES financing instruments, support schemes on energy cost, as well as it takes into account both environmental constrains and technological limitations.

The accuracy of LCOE results highly depends on the analyzed cost structure. Scientific literature suggests analyzing three groups of cost – investment cost, O&M cost and fuel cost. Investment cost of RES technology consists of equipment purchase costs, balance of system cost and installation cost. This cost incurs during the time of RES technology implementation and usually it is sustained during longer periods of time (for example in several years). Since high initial investment cost is necessary, RES technology implementer uses both own and borrowed financial resources. Seeking to comprehensively assess cost, interest during construction (further in the text IDC) is taken into consideration. Thus, total investment cost is calculated regarding Eq. (2):

$$I = \mathrm{IDC} + I_{on} \tag{2}$$

where IDC – interest during construction, EUR; I_{on} – overnight investment cost, EUR.

Several different ways are used to compute IDC, but for simplicity reason a linear approach is used in this paper. IDC is computed considering Eq. (3)

$$\mathrm{IDC} = \sum_{j=1}^{k} I_j \cdot (1+i)^{k-j} \tag{3}$$

where i – interest rate, %.

Microeconomic literature suggests two groups of O&M cost – fixed, which does not depend on generation output, and variable, which is directly influenced by generation output. Variable cost also includes environmental taxes. Assessment of O&M cost is computed considering Eq. (4)

$$O\&M_t = FC_t + VC_t \tag{4}$$

where FC_t – fixed cost, EUR; VC_t – total variable cost, EUR.

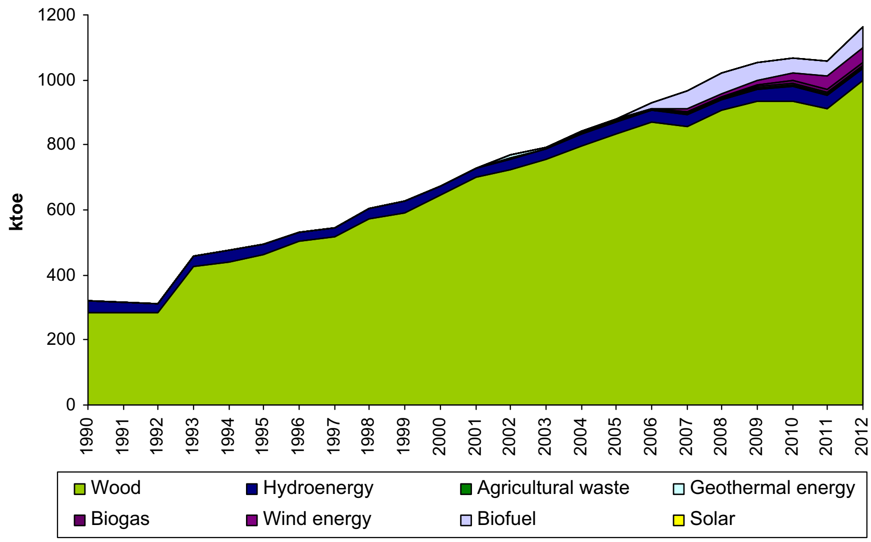

Fig. 3. Development of RES gross inland consumption in Lithuania during 1990–2012 [43].

Total variable cost is computed considering Eq. (5)

$$VC_t = C_I \cdot 8760 \cdot LF \cdot (VC'_t + ET_t) \tag{5}$$

where VC'_t – variable cost per unit of energy produced, EUR/kWh; ET_t – environmental taxes, EUR/kWh.

In this paper fuel costs are computed considering the following factors: installed capacity, load factor and efficiency. Computation of fuel cost is based on Eq. (6)

$$F_t = \frac{LF_t \cdot C_I \cdot 8760 \cdot P_F}{E} \tag{6}$$

where P_F – fuel price, EUR/kWh; E – efficiency, in part shares.

Since RES technologies receive various forms and levels of support, as well various financing instruments are used, therefore LCOE takes this into account. Besides the possibility to trade emission allowances is also foreseen and degradation rate of RES technology is added. Thus Eq. (7) provides the extended approach of LCOE:

$$\mathrm{LCOE} = \frac{\sum_{t=0}^{T}((I_t + O\&M_t + F_t - PTC_t - ITC_t - ATL_t)/(1+d)^t) - (RV/(1+d)^T)}{\sum_{t=0}^{T}(C_I \cdot 8760 \cdot LF \cdot (1-DR)^t)/(1+d)^t} \tag{7}$$

$$ATL_t = (F_t \cdot EF - ATL_{ft}) \cdot ATL_P \tag{8}$$

where PTC_t – subsidy for energy production, EUR; ITC_t – investment subsidy, EUR; RV – residual value, EUR; ATL_t – income/cost for emission allowances, EUR, EF – CO_2 emission coefficient, t; ATL_p – price of emission allowance, EUR/t;ATL_{ft} – number of free emission allowances; DR – degradation rate of technology, % per year.

The extended LCOE approach allows assessing the effect of all currently existing support schemes (alone or in combination with other financial instrument) on energy cost; it also allows comparing LCOE and assessing the investment attractiveness for the investor.

5. Lithuanian experience in financing renewable energy sector

5.1. Development of RES consumption

After the recovery of independence in 1990, the consumption of RES was very low in Lithuania. It amounted only to 320.3 kt of oil equivalent (further in the text ktoe) and made only 2% in gross inland energy consumption in 1990 (see Fig. 3).

Because of implemented renewable energy support policy, RES gross inland consumption was increasing by 6.1% a year during 2000–2012. In 2012, RES gross inland consumption amounted to 1164.8 ktoe (10.4% in gross inland energy consumption). Currently wood and wood waste dominate the structure of RES. In 2012, wood and wood waste covered 85.7%, biofuels – 5.4%, hydro energy – 3.1%, wind energy – 4.0%, biogas – 1.0%, agricultural waste – 0.4%, geothermal energy – 0.3% and solar energy – 0.02% of the total RES consumption. 402.8 ktoe of these RES were transformed in power and heat plants for heat and electricity production in 2012.

Households are the main consumers of RES. However, during Lithuanian rapid economic development period households were tended to reduce RES consumption by 3.3% a year. This reduction was covered by the increased consumption of natural gas and electricity. During the period of national economy slowdown the common structure of fuel consumed in household sector changed. Again, households increased consumption of wood and wood waste. In 2009, 71.9% of RES have been consumed in households, 11.2% – in industry, 9.2% – in transport, 5.2% – in trade and service, 1.9% – in agriculture, 0.5% – in construction. During time of recovery of economy (2011–2012), RES final consumption reduced by 1.5% in 2011 and increased by 3.9% in 2012. With reference to data of 2012, households consumed 560.9 ktoe of RES. This is 74.3% in final RES consumption. Industry consumed 10.9% of RES, transport sector – 8.1%, trade and service – 4.6%, agriculture and fishery – 1.6%, and construction – 0.5%. Increase in RES consumption was highly related to increasing investment in the renewable energy sector. This investment is mainly driven by governmental actions, which are analyzed in the next section of the paper.

5.2. Existing renewable energy financing channels and instruments

Although the review of experience of developing and developed countries showed that renewable energy sector worldwide could be financed using various financing channels and instruments, experience of Lithuania discloses that thus far traditional financing channels and instruments are used to finance the renewable energy sector in Lithuania. The main reason for this is that financial institutions have little experience in financing renewable energy sector; moreover, there is no stability in renewable energy sector regulations, which increase risks to the financial institutions.

Table 3
Feed-in tariff for RES-E [50].

Technology	Maximum feed-in tariff set by NCCEP in 2011, EURct/kWh	Maximum feed-in tariff set by NCCEP in 2012, EURct/kWh	Maximum feed-in tariff set by NCCEP in 2013, EURct/kWh	Actual feed-in tariff received by winners of the auctions, EURct/kWh	Average electricity market price in 2013, EURct/kWh
Wind, connected to transmission network	8.7	8.1	7.5	7.0–7.1	5.1
Wind, connected to distribution network	8.7	10.4	9.3	7.2–10.4	5.1
Hydro	7.5	7.8	7.0	7.8	5.1
Biogas, processing of biodegraded waste	8.7	16.8	13.9–14.8	13.6	5.1
Biogas, using landfill gas	8.7	16.8	9.6–9.8		5.1
Biomass	8.7	13.0	9.8–13.0	9.7	5.1
Solar	Depending on the capacity, feed-in tariff varies in a range of 13.9–52.10 EURct/kWh			N/A	5.1

Nonetheless, financial institutions are actively seeking for new niches and renewable energy projects are on their horizon.

5.2.1. *Electricity sector*

Feed-in tariff system. Renewable energy support policy in Lithuania was established in 2002, when feed-in tariff system for electricity produced from RES started being applied. It set a fixed price for electricity produced from RES (further in the text RES-E). Approved tariffs promoted RES-E generation. Since 2002 RES-E generation volume increased more than 20 times from 41 GWh (2002) till 831.76 GWh (2012). Electricity production volume in wind power plants increased the most and with reference to data of 2012, wind electricity covered 64.6% of the structure of RES-E. Since 2010 feed-in tariff was approved for electricity from solar. Guaranteed feed-in tariff was applied for 2.4 GWh of electricity in 2012.

According to the Law on Renewable Energy Sources, which was implemented in 2011, feed-in tariff was provided in accordance with the installed capacity [42]. During the first year of implementation of the Law, fixed feed-in tariff was paid for RES-E, which was produced in the power plants of capacity less than 30 kW. Feed-in tariff was differenced in accordance with the type of technology. Legally there was no regulation for the total size of capacity for which feed-in tariff could be paid.

The difference between feed-in tariff and electricity market price was paid to RES-E, which was produced in the power plant of more than 30 kW. Legally it was determined that feed-in tariff will be paid for generators that receive promotional quota. The total promotional quota for wind was 260 MW, biofuel – 230 MW, biogas – 75 MW, hydro – 14 MW, and solar– 10 MW. Promotional quota was allocated in the auction, which was organized by the National Control Commission for Energy and Prices (further in the text NCCEP). NCCEP also announced the maximum feed-in tariff for each technology but the producers provided proposals for a price that did not exceeded the maximum feed-in tariff. Feed-in tariff for solar technologies seemed to be too high and regulations too low; therefore such conditions generated a boom in the solar sector. As a result provision of support was suspended.

In 2013, the Law on Renewable Energy Sources was updated. According to the latest amendments, feed-in tariff is paid for RES-E, which is produced in the power plants of capacity less than 10 kW and more than 10 kW. Currently, promotional quotas are set for both groups investors in the auction, which is organized by NCCEP. Feed-in tariff is provided for 12 years since the license to produce electricity is issued. Table 3 provides information on the average size of subsidy for RES-E.

Table 4
Allocation of financial resources in a form of subsidy under the EIF program.

	2010	2011	2012
Wind	1,034,710 EUR	–	0
Solar	–	31,227 EUR	0
In percent from total financing in that year, %	47.8%	59.9%	0

As seen from Table 3, maximum feed-in tariffs for wind electricity, when power plant is connected to the transmission system, are by 7.1% higher than the actual feed-in tariff agreed with the auction winner. The agreed feed-in tariff was by 2 EURct/kWh higher than the average electricity market price in 2013. In case of wind connected to the distribution network, the agreed feed-in tariff was higher than the average electricity market price by 40–104%. Biogas example discloses that depending on the technology, agreed feed-in tariff is higher than the electricity market price by 2–3 times. Solar case shows that up to now there is no approved and agreed with auction winner feed-in tariff. Thus, it is interesting to analyze what the reasons are for such a situation. LCOE of solar electricity could disclose this.

Environmental Investment Fund. RES-E generators, who do not participate in the feed-in tariff system, can apply for the financing provided by Environmental Investment Fund (further in the text EIF) [15]. Investment projects under the EIF program are financed using financial resources from the state budget, i.e. by using 30% of the taxes levied on the environment pollution. These financial resources are committed and provided to beneficiaries in the form of a subsidy. The maximum subsidy to one beneficiary does not exceed 199.84 thousand EUR for three years. Subsidy covers up to 80% of the total eligible cost. Table 4 provides information on the allocation of financial resources in a form of subsidy under the EIF program.

In addition to the EIF program, EIF implements Climate Change Special Program (further in the text CCSP). CCSP is financed through financial resources received from selling emission allowances and from voluntary financial resources provided by legal and natural persons. Promotion of RES utilization and implementation of environmentally friendly technologies are directions under which subsidies and soft loans are provided. The maximum subsidy level for entity that executes commercial activity is 199.8 thousand EUR and for entity that executes non-commercial activity, it is 1.5 million EUR. In any case subsidy cannot exceed 80% of the total eligible cost. In 2012, an invitation to submit

proposals under measure "RES utilization in individual buildings, which were built in accordance to technical building norms applied till 1993" was published. Total financing resources that could be allocated were 260.66 thousand EUR. Subsidy could cover 30% of the total eligible cost. Up to April 2013, there were allocated 72 thousand EUR in the form of subsidy for renewable energy project implementation.

Banks and credit unions also provide financing to RES-E generators in the form of a loan. The first bank that was interested in renewable energy projects was Swedbank. During 2005–2009 Swedbank invested more than 130 million EUR in environmentally friendly technologies, mainly, wind [2]. The interest of bank in financing wind parks increased significantly in 2009, when subsidy in the form of feed-in tariff increased from 5.8 EURct/kWh to 8.7 EURct/kWh. The largest Lithuanian bank called SEB bank also provides loans to wind parks development. In 2009, SEB bank provided a loan of 7.24 million EUR for construction of wind park and later its lending increased till 16.25 million EUR (covering 75% of the total project value) for the construction of a new wind park of installed capacity of 13.8 MW. Besides, 42 million EUR loan in equal shares with Finish bank Pohjola Bank Plc for construction of the largest wind farm (of 39.1 MW) in Lithuania [3] was also provided. SEB bank found attractive biomass technologies too; however, it was only since 2009, when feed-in tariff was increased from 7.0 EURct/kWh to 8.7 EURct/kWh. In 2009, SEB bank provided 6.66 million EUR loans for the construction of biomass-fired CHP.

Banks' interest in renewable energy sector highly increased, when the Law on Renewable Energy Sources was implemented, and high feed-in tariffs were approved. Since high and long-term feed-in tariff for solar electricity was approved, the demand for such types of plants drastically increased. The interest of banks in the solar sector also increased. As a result Medicina Bank decided to finance two solar PV projects, the total installed capacity of which is 1 MW. Total projects value is 2 million EUR. Value of the first project, which has been already implemented, was 0.98 million EUR. Medicina Bank provided a loan of 0.75 million EUR with a loan repayment period of 5 years [46].

Thus, by summarizing it could be stated that renewable energy support policy evolves in Lithuania and brings instability for investors. As a result finance from private sector is limited and traditional financing instruments are offered. The analyses revealed that solar sector is the most influenced by changes in renewable energy policy. Due to high cuts of feed-in tariffs for solar electricity, there is some doubt about this sector's development in future. Thus, the solar PV sector is chosen for further investigations.

5.2.2. Heat sector

There is no direct subsidy in the form of feed-in tariff for heat produced in plants utilizing RES.

Environmental Investment Fund. However, subsidy and soft loans for renewable energy technologies used in heating sector are provided under the EIF program. In 2010, 3.79 million EUR were invested in biomass technologies used to generate heat. Investment volume reduced till 1.24 million EUR in 2011. Investment through CCPS was also provided. With reference to data of 2012, 5.7 million subsidies were offered to finance biomass projects.

EU Structural Funds. Subsidies to heat sector are also provided from EU Structural Funds for the period 2007–2013. Lithuania implements Cohesion promotion action program. In the framework of this program subsidies are provided under the measure "RES utilization for energy production". At the end of 2012, beneficiaries asked for 164 million EUR, but 29 financing agreements were made, the total value of which is 61.9 million EUR. The subsidy level varies in the range of 28.96 thousand EUR – 5.2 million EUR. Intensity is 50%. The remaining financial resources are covered by the private investors and using own financial resources. No governmental assistance is foreseen for the implementation of the measure. There are examples when biomass-related projects are co-financed using various financing channels; however, financial instruments are typical – subsidy and loan. In 2010, in Siauliai city biomass-based combined cycle heat and power plant was started. The support from EU Structural Funds was 5.2 million EUR. Heat-generating company used 1.0 million EUR of its own financial resources for the project. The other financial resources were received from European Investment Bank (further in the text EIB) (10.89 million EUR) in the form of loan. SEB bank and Swedbank (13.61 million EUR) provided a syndicated loan [60].

Tax measures do not make incentives to use RES in heat sector, except excise tax, which considers that biomass is not taxable.

The analysis of financing channels and instruments in Lithuanian heating sector disclosed that biomass is recognized as a type of RES which has possibilities to penetrate the Lithuanian heating market, which currently is based on combustion of natural gas. However, thus far there is no information about possibilities of other renewable energy technologies to enter the heating market. Thus, this paper will fulfill the gap and will reveal the place (competitiveness) of solar collectors in portfolio of energy generation technologies.

5.3. Possible renewable energy financing channels and instruments

The worldwide experience suggests that various financial channels and instruments are used to support energy from RES. Lack of knowledge, shortage of experience and low stability of regulation of renewable energy sector in Lithuania dictate the mode that traditional financing channels and instruments are used in Lithuania. However, this section of the paper will disclose innovative financial channels and instruments that could be more widely used in Lithuania with special emphasize on the solar sector.

5.3.1. JESSICA initiative

JESSICA initiative is a Joint European Support for Sustainable Investment in City Areas. It supports sustainable urban development and regeneration through financial engineering instruments such as stock capital, loans and warranties. Since the beginning of 2008 Lithuanian Ministry of Finance together with EIB analyzed JESSICA's implementation possibilities in Lithuania. It was decided that JESSICA funds will be allocated to the sector of old multifamily houses, which were built before 1993. It was agreed that funds must be directed to the implementation of energy efficiency measures. For this purpose JESSICA controlling fund was established. 227 million EUR (127 million EUR came through EU structural assistance and 100 million EUR from the state) were directed for the implementation of this measure, which aims at improving financing conditions of multifamily houses, higher education schools and student dormitories. The EIB selected three banks (namely, Swedbank, SEB bank and Siauliu bank) in Lithuania, which finance the projects. Banks finance up to 100% of construction costs. Soft loans are provided for 20 years with 3% fixed interest rate. JESSICA controlling fund foresees to support various activities related to the repair and reconstruction of the building. It is also favorable to the renewable energy sector, since it provides assistance in the form of soft loans for installation of RES technologies into the buildings. This is an important channel for the finance renewable energy sector in Lithuania and should be more widely applied.

5.3.2. JEREMIE initiative

The JEREMIE controlling fund was established at the end of 2008 in Lithuania after Ministries of Finance and Economy and European Investment Fund conducted an agreement for the establishment of JEREMIE controlling fund. 210 million EUR were directed to this fund. The peculiarity of the fund is that it provides risk capital to SME through several risk capital funds:

- *LitCapital I* (JSC "LitCapital Asset Management" is a manager of it) was established in 2010 as a development capital fund, which invests into the business development of Lithuanian private micro-, small- and medium-sized enterprises. Fund is oriented into the several branches of the economy: namely, IT, services (B2B, B2C), manufacture of commodities and bioenergy sectors. Fund investments are long-run and are made in a form of purchasing of stocks of the company. Mainly fund invests 0.6–3.0 million EUR for 3–6 years into fast growing companies. After the end of the investment period, it sells stocks. Currently, the portfolio of the LitCapital consists of 7 companies, 1 of which is directly related to the renewable energy sector. This is bioenergy JSC "Lignoterma". JSC "Lignoterna" signed an agreement of 0.87 million EUR (planned total project value 6.4 million EUR). These financial resources will be used to construct 26 MW biomass plant in Panevezys city. Plant will produce heat energy that will be supplied to one of the biggest manufacturing companies in Panevezys – SC "Amilina".
- *Lithuania SME Fund* was established in 2010 by Baltcap fund. It will invest in some Lithuanian small and medium-sized enterprises. Currently, Baltcap is the largest private and risk capital fund in the Baltic States. Lithuania SME Fund will invest 20 million EUR in 7–15 Lithuanian companies, which will be selected by Baltcap.
- *Business Angels Fund I* invests in several Lithuanian small and medium-sized enterprises, whose turnover reaches 4.3 million EUR a year, sales oriented towards export markets, and company functions 1.5–2 years. Fund invests only together with the business angel. Fund together with business angel seeks to acquire 50% of stocks of the company. JSC "Baltic Sun Energy" has been already included into the portfolio of the fund. Fund and the business angel financed solar power plant.

5.3.3. INVEGA fund

INVEGA fund was established in 2009 on the basis of JEREMIE initiative. Fund activities are based on a lending principal, which means that the fund provides selected banks with the financial resources. Later, banks lend these financial resources on their own risks to SME. Fund does not accept risks related to lending, and it does not cover loan administration costs that are sustained by banks. Financial resources are allocated to SME in the form of soft loan, whose conditions are agreed with a bank and are a result of negotiations. INVEGA fund provides up to 100% capital. Banks must pay 3–4% interest rate to fund for their financial resources. INVEGA fund manages the following measures: small credit provision–2 stage, open credit fund, shared risk loans, portfolio guarantees. These measures are favorable to renewable energy sector financing. In a framework of the measure "Small credit provision–2" renewable energy related company could receive a loan up to 100 thousand EUR. This loan is provided to finance investments and working capital. When banks provide renewable energy companies with loans they cannot ask a mark-up that is higher than 2.2%. Considering the fact that basic interest rates are very low, this seems an attractive option to renewable energy related company to borrow money during the slow economic recovery period. Measure "Open credit fund" could be attractive to renewable energy related companies that require finance for investment and working capital up to 435 thousand EUR. The experience of Lithuanian companies disclosed that during 2009–2013 Q1 more than half of the credits were supplied to finance working capital. These credits were provided with higher interest rate (3 month EURIBOR or VILIBOR+0.1%+bank mark-up, which cannot be higher than 3%) than under the measure "Small credit provision–2". Large renewable energy project could be financed using measure "Shared risk loans". Under this measure renewable energy projects could receive loans up to 4.8 million EUR. Renewable energy related companies could also use measure "Portfolio guarantees". This measure is dedicated to promote SME lending by guarantying 80% of loan. In this case the barriers to renewable energy related company to receive finance, when there is shortage of collateral, would be reduced.

INVEGA fund also offers "Innovations development" measure. The measure aims at promoting transmission of ideas generated in scientific institutions to business. In this case renewable energy related companies could practice the most innovative business development ideas created by scientific institutions. In a framework of this measure risk capital is provided. Measure is implemented through Practica Capital company, which manages two funds – Practica Seed Capital fund and Practica Venture Capital fund. Comparison of funds is provided in Table 5.

Thus, results of analysis suggest that JEREMIE initiative should be attractive to renewable energy related companies since innovative measures and good financing engineering instruments are provided under the framework of this initiative. It provides real opportunities for companies to solve business financing issues.

6. Assessment of impact of financing instruments on the costs of solar energy and discussion

The analysis of possible financing channels and instruments for Lithuania allows distinguishing loan as an instrument for financing solar technologies and further development of the solar sector in Lithuania. This section of the paper is dedicated to disclosing how instruments provided under JESSICA and JEREMIE initiatives, as well as investment subsidies are favorable to finance solar sector in Lithuania and how application of these instruments could affect solar energy costs. The main assumptions for calculation of energy cost are provided in Table 6.

Computation of LCOE of solar energy was performed considering a discount rate of 3%, 8%, 10% and 12%. Solar PV technology and solar collectors in a small multifamily house were analyzed regarding the following financing structure:

- *hard loan financing* – in this scenario it was assumed that total investment costs were covered using bank loan, whose interest rate is 7% and repayment period 10 years;
- *soft loan financing* – in this scenario it was assumed that JESSICA funds will be used. Total investment cost will be financed using soft loan, whose annual interest rate is 3% and loan repayment period 20 years;
- *venture capital financing* – in this scenario it was assumed that JEREMIE funds will be used. Risk capital is invested for 6 years and desired profitability of risk capitalist is 30% a year;
- *investment subsidy financing* – in this scenario it was assumed that funds through EIF are available to finance solar technologies. Investment subsidy is 30% of the total eligible cost.

The results of computation of LCOE for solar PV technology are provided in Fig. 4.

Results of computations provided in Fig. 4 show that soft loan and investment subsidy are more preferable than hard loan.

Table 5
Comparison of Practica funds [52,17].

Criteria	Early stage risk capital fund	Risk capital fund
The main investment stage	Early stage "seed, start-up" business financing.	Development financing (working capital, investments.).
Object for investment	Initial business ideas, projects, micro, small and medium-sized enterprises, which develop new business concepts.	Existing micro, small-, medium-sized enterprises.
Geography	Enterprises established and functioning in Lithuania.	
The main form of investment	Ownership (shares) and semi-ownership (convertible debts) capital.	
Planned shares of ownership	Small and large portfolios of shares or semi-ownership financing.	
Size of investment	3000–200,000 EUR per project.	200,000–3 million EUR per project.
Investment period	2–5 years.	2–5 years.
Business sectors	Various business sectors, priority to IT and innovative business.	Various business sectors.
The main selection criteria	– strong team; – quality of business idea; – large market or clear niche of the market; – possibility to test the idea with relatively small investment.	– clear business model; – strong team of leaders; – priority to strong business with good history, share of domestic market, positive and stable cash flow, high capital return.
Participation in management	Active investor who contributes to the creation of high value added and participates in the board.	
Exit from activities	Selling to strategic investor or business leaders; as well bank re-financing.	

Table 6
Assumptions for assessment of renewable energy cost.

Parameters	Criteria	Solar PV technology	Solar collector in a small multifamily house
Technical	Installed capacity, kW	25.0	7.5
	Regression coefficient, %	1.0	0.0
	Electricity production, MWh/year	24.0	–
	Heat production MWh/year	–	13.14
	Lifetime, years	23	23
Cost	Fixed cost, EUR/kW/year	5.0	1.5
	Variable cost, EUR/MWh	1.0	6.4
	Investment cost, EUR/kW	2000	400

Venture capital, having high requirements for profitability, results in higher solar PV energy cost and should be applied only when commercial loans are not available. As seen from Fig. 4, LCOE of solar PV was at least 20% higher than a maximum feed-in tariff (which was 15.06 EURct/kWh in 2014 Q1) set for this technology by Lithuanian NCCEP. The results of computation showed that none of the analyzed financing instruments is suitable for financing solar PV technologies in Lithuania; moreover, existing maximum feed-in tariff does not cover the energy cost of solar PV. As a result development of solar PV technologies is impeded in Lithuania. With reference to data of 2012, a maximum feed-in tariff was set very high (41.71 EURct/kWh in 2012), when LCOE varied in the range of 18.44 EURct/kWh (if soft loan is used) – 30.30 EURct/kWh (if hard loan is applied). Full financing of investment cost with venture capital was not favorable to investors in 2012 too, since LCOE of solar PV subject to venture capital financing was 42.81–63.59 EURct/kWh, when the maximum feed-in tariff was 41.71 EURct/kWh.

The results of computation of LCOE for solar collectors are provided in Fig. 5.

As seen from Fig. 5 soft loan and investment subsidy are the most attractive financing instrument to finance solar collectors in a small multifamily house. LCOE of solar collectors in the case of soft loan varies in the range of 2.85–2.94 EURct/kWh. It is slightly higher if 30% investment subsidy is chosen. LCOE of solar collectors increases by 70% if hard loan is used instead of soft loan and by 2.5 times if venture capital funds are used. Seeking to disclose solar collector attractiveness, average heat prices in Kaunas and Varena are presented in Fig. 5. Kaunas city data were chosen because natural gas is the main fuel combusted in a district heating sector of Kaunas city. Its share in fuel structure was 92% in 2012, when solid biomass constituted only 3.6% of the fuel structure. Varena city combusts mainly solid biomass. The share of solid biomass constituted 82% of the total fuel structure in 2012. The comparative analysis of LCOE of solar collectors and heat prices in Kaunas and Varena cities showed that heat energy from solar could be an attractive alternative for consumers, since LCOE of a solar collector is relatively lower. Thus it could be argued that biomass technologies could compete with solar technologies if soft loan, investment subsidy and hard loan are used to finance the solar project. Venture capital is not attractive in cities where biomass could be used. However, venture capital could be used to finance solar collectors in cities where natural gas is widely combusted.

Thus by summarizing what was said it could be argued that seeking to expedite solar sector development in Lithuania it is essential to update feed-in tariff, which currently is too low and impedes implementation of solar PV technologies. The results of computation disclose that soft loan provided under the JESSICA initiative and investment subsidy given by EIF are instruments which could contribute to increased consumption of solar electricity in Lithuania. Favorable conditions of these instruments impact low solar electricity cost. Thus policymakers should consider these instruments when preparing electricity sector development plans and organizing support schemes for development of solar PV technologies in Lithuania. Solar collectors for heat energy production are valid in small multifamily houses in Lithuania. It is practical to install solar collectors even under market conditions – using hard loans provided by banks. This shows that solar collectors could compete in the district heating market even without any support. However, if they are implemented at the end user point, they could create higher (additional) district heating cost for the rest of the costumers.

7. Conclusions

Because of benefits provided by RES and ability of the renewable energy sector to solve various environmental, social, economical and political issues worldwide, RES demand and RES consumption have a tendency to increase. Renewable energy

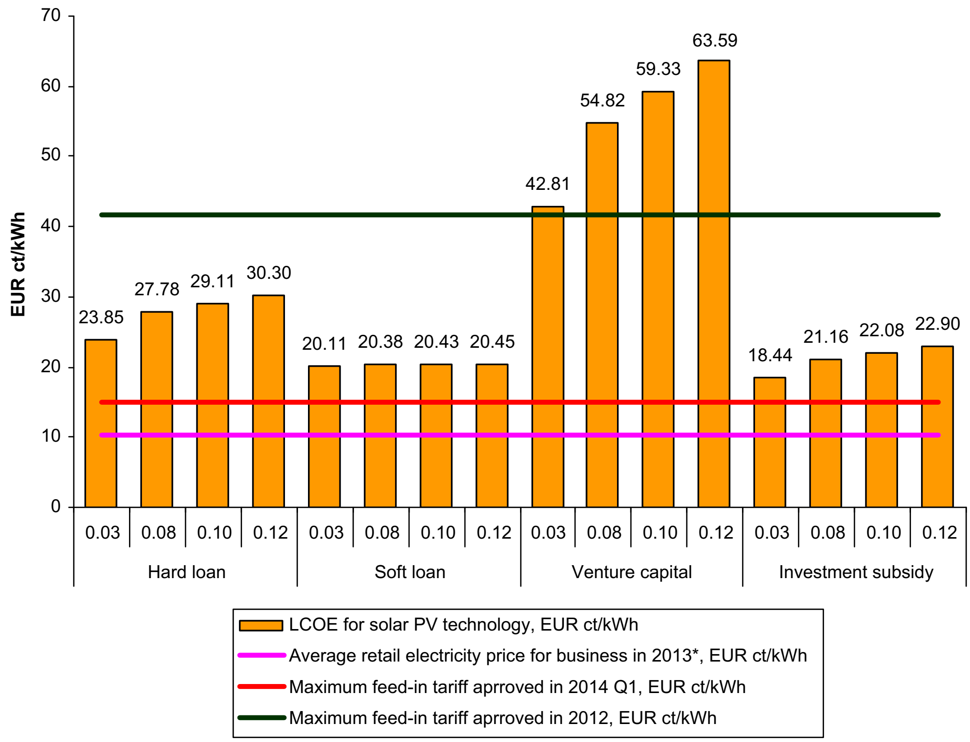

Fig. 4. LCOE for solar PV technology (own calculations). * – value added tax is excluded.

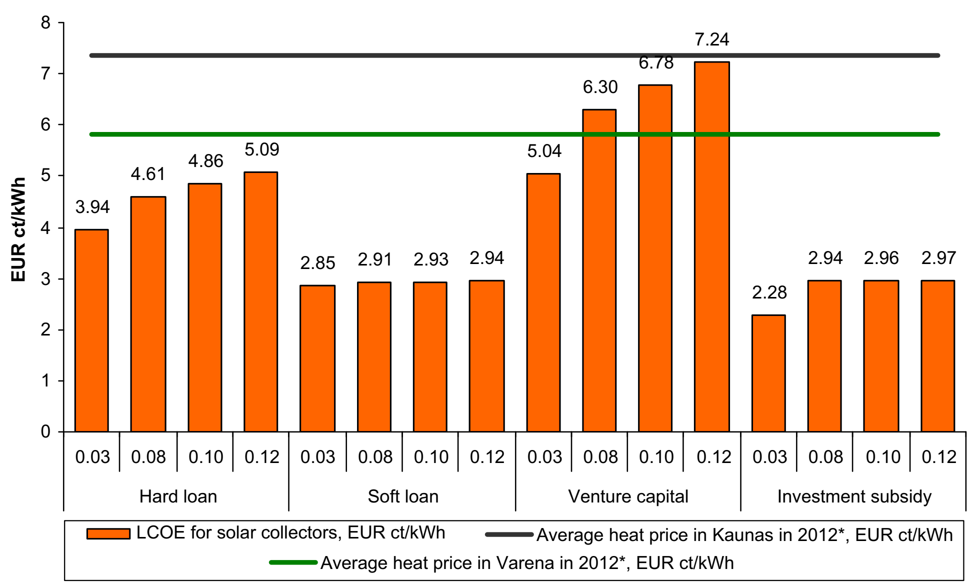

Fig. 5. LCOE for solar collectors in a small multifamily house (own calculations). * – value added tax is excluded.

sector growth rates become high. Although biomass is the dominant type of RES, wind and solar utilization is increasing rapidly. It is considered that demand for RES, as a sustainable fuel, will increase in future. Seeking to satisfy increasing demand for RES and energy, investment is required.

Some financing channels have been developed through which investment into the renewable energy sector could come. The analysis revealed that governments, multilateral development banks, regional development banks, commercial banks and EU are important renewable energy sector financing channels in developing countries. Due to the renewable energy sector's ability to solve regional issues and because of established support policy participation of private sector increases. The results showed that availability to use financial channels also depend on income level, type of RES, and technology implemented. Formal financing channels become available, when income level increases. Renewable energy sector attracts more investment in approved technologies and type of resource which is abundant in the country.

The analysis of experience of developed countries disclosed that investment into the renewable energy sector of these countries can come through government, banks, venture capital funds, private equity funds, pension funds, sovereign funds and others. Policy measures and policy targets implemented to support renewable energy sector contribute to increasing amount of private sector participation. Private financial resources come from debt market, equity market or capital market.

Results of the analysis revealed that the availability of financial channels depend on the stage of life cycle of renewable energy sector development. Because of high risk technology research activity is mainly financed using public financial sources, such as grants or subsidies. When technologies move out of research to the development stage, the amount of public financing reduces. Venture capital and privative equity come into place. Because of the high level of risk and dismissal of the requirements held by financial institutions for receiving loans, in early stage of technology development, renewable energy technology developer is not capable of receiving financing from credit/debt markets. Financial sources of credit market are available when RES plants are constructed.

Traditional renewable energy sector financing instruments are used worldwide. They are subsidy, loan and equity. During times of economic recession availability to receive loan is reduced. Although Libor reduced, however, banks considered renewable energy sector of high risk and were risk-averse, and therefore set high spreads for loan and reduced loan repayment period. Nowadays various modifications of traditional instruments are available. This is the case of mezzanine finance. Thus far Green bonds and notes are issued. They all help to raise the capital and increase investment into the renewable energy sector.

The analysis of financing channels and instruments in Lithuania revealed that feed-in tariff is the most important instrument used to facilitate investment in the renewable energy sector. Electricity and heat production from RES are financed using public sources – EIF provides subsidies and soft loans. Besides, EU Structural Funds are available. Renewable energy sector projects are financed using a mix of financing channels – own resources, resources from EU, European investment bank and commercial banks. Commercial banks found renewable energy sector attractive only since 2009, when feed-in tariffs were increased.

Innovative financing instruments provided under JESSICA and JEREMIE initiatives, as well as investment subsidies are favorable to develop the solar energy sector in Lithuania. Seeking to expedite solar sector development in Lithuania it is essential to review feed-in tariff, which currently is too low and impedes implementation of solar PV technologies. Soft loan provided under the JESSICA initiative and investment subsidy given by EIF are instruments which could contribute to increased consumption of solar electricity in Lithuania. Policymakers should consider these instruments when preparing electricity sector development plans and organizing support schemes for development of solar PV technologies in Lithuania. Solar collectors for heat energy production are valid in small multifamily houses in Lithuania. It is rational to install solar collectors even under market conditions – using hard loans provided by banks. This shows that solar collectors could compete in a district heating market even without any support. However, if they are implemented at the end user point, they could create higher (additional) district heating cost for the rest of the costumers.

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References

[1] Asian Development Bank. Clean energy program: accelerating low-carbon development in Asia and the pacific region. 〈http://www.adb.org/sites/default/files/pub/2012/clean-energy-program-brochure.pdf〉; 2012 [accessed 15.08.13].

[2] Balsas LT. Sūdėnuose pristatytas pirmasis "4 Energia" vėjo jėgainių parkas. 〈http://www.marketnews.lt/naujiena/sudenuose_pristatytas_pirmasis_4_energia_vejo_jegainiu_parkas;itemid=10704〉; 2009 [accessed 08.11.12].

[3] Balsas LT. Lietuvos verslas Pasaulio verslas Rinkos naujienos Sėkmės istorijos Tyrimai Transportas Medija Žemės ūkis "Balsas.lt savaitė" Bendrovei "Naujoji energija" suteikta 145 mln. litų paskola. 〈http://www.balsas.lt/naujiena/547291/bendrovei-naujoji-energija-suteikta-145-mln-litu-paskola〉; 2011 [accessed 08.11.12].

[4] Behrens A. The financing of the Global Energy Efficiency and Renewable Energy Fund (GEEREF). Centre for European Policy Studies. 〈http://www.undpcc.org/undpcc/files/docs/publications/1862.pdf〉; 2009 [accessed 10.12.13].

[5] Benkovic S, Makojevic N, Jednak S. Possibilities for development of the Electric Power Industry of Serbia through private source financing of small hydropower plants. Renew Energy 2013;50:1053–9.

[6] Bloomberg New Energy Finance, Global trends in renewable energy investment 2012 – data pack, 2012, Frankfurt School of Finance & Management. 〈http://fs-unep-centre.org/sites/default/files/attachments/unepglobaltrendsmasterdatapack2012.pdf〉 2012 [accessed 08.08.13].

[7] Blum NU, Wakeling RS, Schmidt TS. Rural electrification through village grids – assessing the cost competitiveness of isolated renewable energy technologies in Indonesia. Renew Sustain Energy Rev 2013;22:482–96.

[8] Bruggink J. Energy aid in times of climate change: designing climate compatible development strategies. 〈http://www.ecn.nl/docs/library/report/2012/e12006.pdf〉; 2012 [accessed 12.11.12].

[9] Bürer MJ, Wüstenhagen R. Which renewable energy policy is a venture capitalist's best friend? Empirical evidence from a survey of international clean-tech investors Energy Policy 2009;37(12):4997–5006.

[10] Canadian Renewable Energy Alliance. Financing sources and mechanisms for renewable energy and energy efficiency. 〈http://www.canrea.ca/pdf/CanREAFinancingPaper.pdf〉; 2006 [accessed 08.11.12].

[11] Croce C, Kaminker R, Stewart F. The role of pension funds in financing green growth initiatives. Paris: OECD Publishing. 〈http://climatebonds.net/wp-content/uploads/2011/09/OECD_Role_of_PFs_in_Financing_GreenGrowth-WP10.pdf〉; 2011 [accessed 08.11.12].

[12] de Moor A. Towards a grand deal on subsidies and climate change. Nat Resour Forum 2001;25:167–76.

[13] Dusonchet L, Telaretti E. Economic analysis of different supporting policies for the production of electrical energy by solar photovoltaics in eastern European Union countries. Energy Policy 2010;38(8):4011–20.

[14] Dusonchet L, Telaretti E. Economic analysis of different supporting policies for the production of electrical energy by solar photovoltaics in western European Union countries. Energy Policy 2010;38(7):3297–308.

[15] Environmental Investment Fund. 〈http://www.laaif.lt〉; 2013 [accessed 02.12.13].

[16] Environmental Protection Agency of USA. American Recovery and Reinvestment Act of 2009: a guide to renewable energy and energy efficiency opportunities for local and tribal governments. 〈http://www.epa.gov/statelocalclimate/documents/pdf/local_guide_to_arra.pdf〉; 2009 [accessed 08.11.12].

[17] ESparama. EU structural funds. 〈www.esparama.lt〉 [accessed 02.12.13].

[18] EUROFIDEME. Investment Fund dedicated to renewable energy project finance in Europe. 〈http://www.eurofideme2.com/en_eurofideme-2_investment-fund_33_39.html〉; 2013 [accessed 10.11.12].

[19] European Commission. Report from the Commission to the European Parliament and the Council on the Implementation of the European Energy Programme for Recovery. 〈http://ec.europa.eu/energy/eepr/doc/com_2012_0445_en.pdf〉; 2012 [accessed 16.02.13].

[20] European Parliament. Regulation (EC) No 663/2009 of the European Parliament and of the Council of 13 July 2009 establishing a programme to aid economic recovery by granting community financial assistance to projects in the field of energy. 〈http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:200:0031:0045:EN:PDF〉; 2009 [accessed 16.11.12].

[21] Federal Ministry for the Environment, Nature Conservation and Nuclear Safety. The Global Financial Crisis and Its Impact on Renewable Energy Finance; 2009.

[22] Fournier G, Rasmussen D. Targeted capital subsidies and economic welfare. Cato J 1986;6(1):295–315 (〈http://www.cato.org/sites/cato.org/files/serials/files/cato-journal/1986/5/cj6n1-14.pdf〉 [accessed 11.11.12]).

[23] Frankfurt School of Finance & Management. Global Trends in Renewable Energy Investment 2012. Frankfurt School of Finance & Management; 2012. 〈http://fs-unep-centre.org/sites/default/files/publications/globaltrendsreport2012.pdf〉 [accessed 15.08.13].

[24] Global Energy Efficiency and Renewable Energy Fund (GEEREF). 〈www.geeref.com〉 [accessed 15.08.13].

[25] Global Village Energy Partnership (GVEP)〈www.gvepinternational.org〉 [accessed 17.08.13].

[26] Grifth-Jones S, Ocampo JA, Spratt, S. Financing renewable energy in developing countries: mechanisms and responsibilities; 2011.

[27] Hernández-Moro J, Martínez-Duart JM. Analytical model for solar PV and CSP electricity costs: present LCOE values and their future evolution. Renew Sustain Energy Rev 2013;20:119–32.

[28] Hofman D, Huisman R. Did the financial crisis lead to changes in private equity investor preferences regarding renewable energy and climate policies? Energy Policy 2012;47:111–6.

[29] Inter-American Development Bank. Integrated strategy for climate change adaptation and mitigation, and sustainable and renewable energy. 〈http://idbdocs.iadb.org/wsdocs/getdocument.aspx?docnum=35802849〉; 2011 [accessed 15.08.13].

[30] Inter-American Development Bank. Latin America and the Caribbean could cover all their electricity needs using renewable resources: IDB report. 〈http://www.iadb.org/en/news/webstories/2013-06-18/renewable-energy-in-latin-america-and-the-caribbean,10486.html〉; 2013 [accessed 15.05.13].
[31] International Energy Agency (IAE). Renewables information: IAE statistics. OECD/IAE; 2005. 〈http://www.oecd-ilibrary.org/energy/renewables-information-2005_renew-2005-en〉 [accessed 08.08.13].
[32] International Energy Agency (IAE). Renewables information: IAE statistics. OECD/IAE; 2011. 〈http://www.oecd-ilibrary.org/energy/renewables-information-2011_renew-2011-en;jsessionid=3huf93tf3uus6.x-oecd-live-02〉 [accessed 08.08.13].
[33] International Energy Agency (IAE). World energy outlook. OECD/IAE; 2011. 〈http://www.iea.org/publications/freepublications/publication/WEO2011_WEB.pdf〉 [accessed 08.08.13].
[34] International Energy Agency (IEA). Energy technology perspectives 2010: scenarios and strategies to 2050. Paris, France: International Energy Agency, IEA/OECD; 2010; 1–706.
[35] Jalilvand J. Renewable energy for the Middle East and North Africa policies for a successful transition. 〈http://library.fes.de/pdf-files/iez/08959.pdf〉; 2012 [accessed 16.11.12].
[36] Justice S. Private financing of renewable energy – a guide for policymakers. 〈http://sefi.unep.org/fileadmin/media/sefi/docs/publications/Finance_guide_FINAL-.pdf〉; 2009 [accessed 15.11.12].
[37] Kalamova M, Kaminker C, Johnstone N. Sources of finance, investment policies and plant entry in the renewable energy sector. OECD Environment Working Papers, No. 37. OECD Publishing. 〈http://www.oecd-ilibrary.org/docserver/download/5kg7068011hb.pdf?expires=1360660915&id=id&accname=guest&checksum=372889DFF45BC66873C4D4BE29175607〉; 2011 [accessed 06.11.12].
[38] Kaminker Ch, Stewart The role of institutional investors in financing clean energy. OECD Working Papers on finance, insurance and private pensions, No. 23. OECD Publishing. 〈http://www.oecd.org/environment/WP_23_TheRoleOfInstitutionalInvestorsInFinancingCleanEnergy.pdf〉; 2012 [accessed 06.11.12]..
[39] Keyuraphan S, Thanarak P, Ketjoy W, Rakwichian W. Subsidy schemes of renewable energy policy for electricity generation in Thailand. Procedia Eng 2012;32:440–8.
[40] Lantz E, Doris E. State clean energy practices: renewable energy rebates. 〈http://www.nrel.gov/docs/fy09osti/45039.pdf〉; 2009 [accessed 11.11.12].
[41] Liming H. Financing rural renewable energy: a comparison between China and India. Renew Sustain Energy Rev 2009;13(5):1096–103.
[42] Lithuanian Parliament. Law on renewable energy sources, No XI-1375 of 12 May 2011. 〈http://www3.lrs.lt/pls/inter3/dokpaieska.showdoc_l?p_id=453899&p_tr2=2〉; 〈http://www3.lrs.lt/pls/inter3/dokpaieska.showdoc_l?p_id=398874&p_tr2=2〉; 2011 [accessed 02.12.13].
[43] Lithuanian Statistics. 〈http://www.osp.stat.gov.lt/web/guest/statistiniu-rodikliu-analize1〉; 2013 [accessed 18.12.13].
[44] Mainali B, Silveira S. Financing off-grid rural electrification: country case Nepal. Energy 2011;36(4):2194–201.
[45] Masdar Capital. 〈http://www.masdar.ae/en/investment/detail/masdar-capital1〉; 2013 [accessed 06.11.12].
[46] Medicina Bank. 〈http://www.medbank.lt/naujienos/8-naujienos/437-medicinos-bankas-finansuoja-saules-elektrines-projektus.html〉; 2012 [accessed 08.11.12].
[47] Mergers Inquisitions. 〈http://www.mergersandinquisitions.com/private-equity-vs-venture-capital〉; 2013 [accessed 16.12.13].
[48] Michael J, Novogradac C. Tax credits are more efficient than cash grants. J Tax Cred II (XI). 〈http://www.novoco.com/journal/2011/11/news_ww_201111.php〉; 2011 [accessed 11.11.12].
[49] Miglo A. Project financing versus corporate financing under asymmetric information. J Bus Econ Res 2010;8(8):27–42.
[50] National Control Commission for Energy and Prices. Approved feed-in tariffs. 〈http://www.regula.lt/lt/atsinaujinantys_istekliai/tarifai/〉; 2013 [accessed 02.12.13].
[51] Olmos L, Ruester S, Liong S. On the selection of financing instruments to push the development of new technologies: application to clean energy technologies. Energy Policy 2012;43:252–66.
[52] Practica. 〈http://practica.lt/〉 [accessed 02.12.13].
[53] Ramadhan M, Naseeb A. The cost–benefit analysis of implementing photovoltaic solar system in the state of Kuwait. Renew Energy 2011;36(4):1272–6.
[54] Reichelstein S, Yorston M. The prospects for cost competitive solar PV power. Energy Policy 2013;55:117–27.
[55] REN21 MAP. Renewables interactive map: renewables policy table, renewable energy promotion policies; 2011.
[56] Renewable Energy & Efficiency Partnership (REEEP). Financing options for renewable energy and energy efficiency. 〈http://africa-toolkit.reeep.org/modules/Module19.pdf〉; 2007 [accessed 15.11.12].
[57] Renewable Energy and Energy Efficiency Partnership (REEEP). REEEP strategy overview 2012–2015. 〈http://www.reeep.org/sites/default/files/REEEP%20Strategy%20Overview%202012-2015.pdf〉; 2012 [accessed 15.05.13].
[58] Rezessy S, Bertoldi P.. Financing energy efficiency: forging the link between financing and project implementation. Report prepared by the Joint Research Centre of the European Commission. 〈http://ec.europa.eu/energy/efficiency/doc/financing_energy_efficiency.pdf〉; 2010 [accessed 15.08.13].
[59] Scholer K, Tan MML. Financing renewable energy projects in the US: case studies and opportunities. 〈http://www.lexology.com/library/detail.aspx?g=4f6a4099-bda6-4042-a1be-fae4f6011ca1〉; 2012 [accessed 15.05.13].
[60] Siauliu Energija. 〈http://www.senergija.lt/Projektai/Projektas-Siauliu-termofikacines-elektrines-statyba/Atidaryta-biomases-kogeneracine-elektrine〉 [accessed 12.11.12].
[61] United Nations Environment Programme (UNEP). Public finance mechanisms to catalyze sustainable energy sector growth; 2005.
[62] United Nations Environmental Programme (UNEP). Rural Energy Enterprise Development (REED). 〈http://www.unep.org/climatechange/finance/SeedCapital/REED/tabid/29554/Default.aspx〉; 2013 [accessed 15.08.13].
[63] Vassilakos N, Karapanagiotis N, Fertis D, Tigas K.. Methods of financing renewable energy investments in Greece. 〈http://www.cres.gr/kape/pdf/download/F_RES.pdf〉; 2003 [accessed 15.08.13].
[64] Vos R, Sawin J. Ready Policies for Accelerated Deployment of Renewable Energy. Renew Energy Action Deploy 2012:159–75.
[65] Wang X, Kurdgelashvili L, Byrne J, Barnett A. The value of module efficiency in lowering the levelized cost of energy of photovoltaic systems. Renew Sustain Energy Rev 2011;15(9):4248–54.
[66] World Bank. Affiliates. 〈http://web.worldbank.org/WBSITE/EXTERNAL/EXTABOUTUS/0,,contentMDK:20040612~menuPK:8336267~pagePK:51123644~piPK:329829~theSitePK:29708,00.html〉; 2013 [accessed 15.08.13].
[67] World Bank. 〈http://web.worldbank.org/WBSITE/EXTERNAL/TOPICS/EXTENERGY2/0,,contentMDK:21651596~menuPK:4140787~pagePK:210058~piPK:210062~theSitePK:4114200,00.html〉; 2013 [accessed 15.08.13].
[68] World Bank. Financing renewable energy options for developing financing instruments using public funds. 〈https://www.climateinvestmentfunds.org/cif/sites/climateinvestmentfunds.org/files/SREP_financing_instruments_sk_clean2_FINAL_FOR_PRINTING.pdf〉; 2013 [accessed 15.08.13].
[69] Wüstenhagen R, Menichetti E. Strategic choices for renewable energy investment: conceptual framework and opportunities for further research. Energy Policy 2012;40:1–10.